CLAIMS

What we claim is:

1. A method for performing thermal coagulation necrosis of biological tissue, comprising:

configuring an electrode array that provides a balanced energy density in at least one target tissue volume using two or more pair of bipolar electrodes having a configuration that includes at least one of irregular spacing between one or more pairs of the electrodes and one or more electrode diameters;

deploying each electrode of the electrode array at a selected depth in the target tissue volume using the configuration;

delivering the balanced energy to the target tissue volume from at least one radio frequency (RF) power source via the electrodes and controlling the delivery in response to at least one of elapsed time of the delivery, a temperature of the target tissue volume, and an impedance of the target tissue volume; and

generating at least one plane of coagulated tissue.

2. The method of claim 1, further comprising positioning an electrode guide on a surface of a biological tissue region that includes the target tissue volume, wherein the electrode guide includes a series of channels that position the electrodes in accordance with the configuration.

3. The method of claim 1, wherein spacing among the electrodes varies according to at least one of a total number of electrodes in the electrode array, the electrode diameters, and the selected deployment depth of each electrode in the target tissue volume.

4. The method of claim 1, wherein spacing among the center-most electrodes of the array is larger relative to spacing among the end-most electrodes.

5. The method of claim 1, wherein configuring the electrode array further comprises forming a linear electrode array that includes a first set of electrodes on each end of the array and a second set of electrodes positioned between the electrodes of the first set, wherein each electrode of the first set has a first diameter and each electrode of the second set has a second diameter.

6. The method of claim 5, wherein the first diameter is smaller than the second diameter.

7. The method of claim 1, wherein controlling the delivery further comprises:

increasing a delivery rate of energy to the target tissue volume by a first amount;

increasing the delivery rate of energy when a rate of increase of the temperature of the target tissue volume is equal to or less than a minimum rate;

decreasing the delivery rate of energy when the rate of increase of the temperature of the target tissue volume is equal to or greater than a maximum rate;

decreasing the delivery rate of energy when the temperature of the target tissue volume is greater than a maximum temperature;

increasing the delivery rate of energy to the target tissue volume by a second amount when the temperature of the target tissue volume is less than the maximum temperature; and

terminating the delivery of energy to the target tissue volume when the elapsed time of the delivery exceeds a maximum time.

8. The method of claim 1, wherein controlling the delivery further comprises:

increasing a delivery rate of energy to the target tissue volume by a first amount;

maintaining the delivery rate of energy when the impedance of the target tissue is decreasing; and

terminating the delivery of energy to the target tissue volume when the impedance of the target tissue exceeds a maximum impedance.

9. The method of claim 8, further comprising further increasing the delivery rate of energy to the target tissue volume by the first amount when the impedance of the target tissue is increasing or remaining approximately constant.

10. The method of claim 1, wherein controlling the delivery further comprises:

determining a first impedance of the target tissue volume;

delivering energy at a first rate to the target tissue volume;

monitoring the first impedance and delivering energy at a second rate when a decrease in the first impedance is less than a first threshold;

determining a second impedance of the target tissue volume in response to the decrease in the first impedance exceeding the first threshold;

monitoring the second impedance and delivering energy at a third rate when a decrease in the second impedance is less than a second threshold; and

terminating the delivery of energy to the target tissue volume when the impedance of the target tissue exceeds a maximum impedance.

11. The method of claim 1, wherein controlling the delivery further comprises:

determining the impedance of the target tissue volume;

delivering the balanced energy to the target tissue volume at a first rate until the impedance stabilizes at a lower impedance; and

delivering the balanced energy to the target tissue volume at a second rate until the impedance exceeds a threshold impedance.

12. The method of claim 1, wherein delivering the balanced energy further comprises supplying a first potential of RF energy to a first set of electrodes in the electrode array and a second potential of RF energy to a second set of electrodes in the electrode array.

13. The method of claim 1, further comprising:

incising the biological tissue in a vicinity of the plane of coagulated tissue; and

resecting a portion of the biological tissue.

14. The method of claim 1, further comprising infusing a solution into the target tissue volume via at least one of the bipolar electrodes, wherein the solution is at least one of a hyper-tonic solution, a hypo-tonic solution, a contrast agent, a sclerotic agent, and a chemotherapy agent.

15. The method of claim 1, wherein at least one electrode of the electrode array further includes at least one of a temperature sensor, a thermocouple, an infusion component, and an optical tissue monitor.

16. The method of claim 1, wherein the balanced energy density includes uniform energy distribution and uniform current density.

17. The method of claim 1, wherein the bipolar electrodes of the electrode array form an alternating polarity series that includes at least one electrode of a positive polarity in series with at least one electrode of a negative polarity.

18. The method of claim 1, wherein the temperature of the target tissue volume includes at least one of a temperature of at least one area of the target tissue

volume, a change in temperature of at least one area of the target tissue volume, and a rate of change of temperature of at least one area of the target tissue volume.

19. The method of claim 1, wherein the target tissue volume is a rectangular volume.

20. The method of claim 1, wherein controlling the delivery further comprises:

delivering a first amount of energy to the target tissue volume for a first period of time;

delivering a second amount of energy to the target tissue volume for a second period of time;

delivering a third amount of energy to the target tissue volume for a third period of time; and

terminating the delivery of energy to the target tissue volume upon expiration of the third period of time.

21. The method of claim 20, wherein the first amount of energy is less than the second amount of energy and the third amount of energy is greater than the second amount of energy.

22. The method of claim 20, wherein the second and third periods of time are less than the first period of time.

23. The method of claim 20, wherein at least one of the first, second, and third amounts of energy are selected in response to the selected depth of deployment of at least one electrode.

24. The method of claim 20, wherein at least one of the first, second, and third periods of time are selected in response to the selected depth of deployment of at least one electrode.

25. The method of claim 1, wherein controlling the delivery further comprises:

delivering at least one amount of energy to the target tissue volume for at least one period of time having at least one duration; and

terminating the delivery of energy to the target tissue volume upon expiration of a pre-specified amount of time.

26. The method of claim 1, wherein controlling the delivery further comprises:

delivering energy at one of a plurality of energy rates during at least one time period in response to the selected depth of deployment of at least one electrode; and

terminating the delivery of energy to the target tissue volume upon expiration of a pre-specified amount of time.

27. A method for generating planes of coagulated tissue in biological tissue, comprising:

configuring an electrode array that provides a balanced energy density in at least one target tissue volume using two or more pair of electrodes having a configuration that includes at least one of irregular spacing between one or more pairs of the electrodes and one or more electrode diameters;

deploying each electrode of the electrode array at a selected depth in the target tissue volume using the configuration;

determining an impedance of the target tissue volume;

delivering the balanced energy to the target tissue volume at a first rate until the impedance stabilizes at a lower impedance; and

generating at least one plane of coagulated tissue in the target tissue volume by delivering the balanced energy to the target tissue volume at a second rate until the impedance exceeds a threshold impedance.

28. The method of claim 27, wherein configuring further comprises varying spacing among the electrodes according to at least one of a total number of electrodes in the electrode array, the electrode diameters, and the selected deployment depth of each electrode in the target tissue volume.

29. The method of claim 27, wherein configuring further comprises spacing center-most electrodes of the electrode array at a larger distance relative to spacing of end-most electrodes of the electrode array.

30. The method of claim 27, wherein configuring the electrode array further comprises forming a linear electrode array that includes a first set of electrodes on each end of the array and a second set of electrodes positioned between the electrodes of the first set, wherein each electrode of the first set has a first diameter and each electrode of the second set has a second diameter.

31. A method for resecting a portion of biological tissue within a mammalian body, comprising:

configuring an electrode array that provides a uniform energy density in at least one target tissue volume using two or more pair of electrodes that include at least one of irregular spacing between one or more pairs of the electrodes and one or more electrode diameters;

deploying each electrode of the electrode array at a selected depth in the target tissue volume using the configuration;

generating planes of coagulated tissue in the target tissue volume by delivering power to the target tissue volume from at least one power source via the electrodes and

controlling the power delivery at two or more rates in response to at least one of elapsed time, a temperature of the target tissue volume, and an impedance of the target tissue volume;

incising the biological tissue in a vicinity of the coagulated tissue; and

resecting a portion of the biological tissue.

32. A system for performing thermal coagulation necrosis of biological tissue, comprising:

means for configuring an electrode array that provides a balanced energy density in at least one target tissue volume using two or more pair of bipolar electrodes having a configuration that includes at least one of irregular spacing between one or more pairs of the electrodes and one or more electrode diameters;

means for deploying each electrode of the electrode array at a selected depth in the target tissue volume using the configuration;

means for generating at least one plane of coagulated tissue by delivering the balanced energy to the target tissue volume via the electrodes and controlling the delivery in response to at least one of elapsed time of the delivery, a temperature of the target tissue volume, and an impedance of the target tissue volume.

33. The system of claim 32, wherein spacing among the electrodes varies according to at least one of a total number of electrodes in the electrode array, the electrode diameters, and the selected deployment depth of each electrode in the target tissue volume.

34. The system of claim 32, wherein spacing among the center-most electrodes of the array is larger relative to spacing among the end-most electrodes.

35. The system of claim 32, wherein the means for controlling the delivery further comprises:

means for increasing a delivery rate of energy to the target tissue volume by a first amount;

means for increasing the delivery rate of energy when a rate of increase of the temperature of the target tissue volume is equal to or less than a minimum rate;

means for decreasing the delivery rate of energy when the rate of increase of the temperature of the target tissue volume is equal to or greater than a maximum rate;

means for decreasing the delivery rate of energy when the temperature of the target tissue volume is greater than a maximum temperature;

means for increasing the delivery rate of energy to the target tissue volume by a second amount when the temperature of the target tissue volume is less than the maximum temperature; and

means for terminating the delivery of energy to the target tissue volume when the elapsed time of the delivery exceeds a maximum time.

36. The system of claim 32, wherein the means for controlling the delivery further comprises:

means for increasing a delivery rate of energy to the target tissue volume by a first amount;

means for maintaining the delivery rate of energy when the impedance of the target tissue is decreasing; and

means for terminating the delivery of energy to the target tissue volume when the impedance of the target tissue exceeds a maximum impedance.

37. The system of claim 36, further comprising means for further increasing the delivery rate of energy to the target tissue volume by the first amount when the impedance of the target tissue is increasing or remaining approximately constant.

38. The system of claim 32, wherein the means for controlling the delivery further comprises:

means for determining a first impedance of the target tissue volume;

means for delivering energy at a first rate to the target tissue volume;

means for monitoring the first impedance and delivering energy at a second rate when a decrease in the first impedance is less than a first threshold;

means for determining a second impedance of the target tissue volume in response to the decrease in the first impedance exceeding the first threshold;

means for monitoring the second impedance and delivering energy at a third rate when a decrease in the second impedance is less than a second threshold; and

means for terminating the delivery of energy to the target tissue volume when the impedance of the target tissue exceeds a maximum impedance.

39. The system of claim 32, wherein the means for controlling the delivery further comprises:

means for determining the impedance of the target tissue volume;

means for delivering the balanced energy to the target tissue volume at a first rate until the impedance stabilizes at a lower impedance; and

means for delivering the balanced energy to the target tissue volume at a second rate until the impedance exceeds a threshold impedance.

40. The system of claim 32, further comprising:

means for incising the biological tissue in a vicinity of the plane of coagulated tissue; and

means for resecting a portion of the biological tissue.

41. The system of claim 32, wherein the balanced energy density includes uniform energy distribution and uniform current density.

42. The system of claim 32, wherein the temperature of the target tissue volume includes at least one of a temperature of at least one area of the target tissue

volume, a change in temperature of at least one area of the target tissue volume, and a rate of change of temperature of at least one area of the target tissue volume.

43. The system of claim 32, wherein the target tissue volume is a rectangular volume having a width approximately in a range of 0.5 centimeter to 1 centimeter.

44. A method for performing thermal coagulation necrosis of biological tissue, comprising:

configuring an electrode array that provides a balanced energy density in at least one target tissue volume using two or more pair of bipolar electrodes having a configuration that includes at least one of irregular spacing between one or more pairs of the electrodes and one or more electrode diameters;

deploying each electrode of the electrode array at a selected depth in the target tissue volume using the configuration; and

generating at least one plane of coagulated tissue by delivering the balanced energy to the target tissue volume from at least one power source via the electrodes by delivering energy at one of a plurality of energy rates during at least one time period in response to the selected depth of deployment of at least one electrode.

45. A tissue ablation system, comprising:

means for configuring an electrode array that provides a balanced energy density in at least one target tissue volume using two or more pair of bipolar electrodes having a configuration that includes at least one of irregular spacing between one or more pairs of the electrodes and one or more electrode diameters;

means for deploying each electrode of the electrode array at a selected depth in the target tissue volume using the configuration; and

means for generating at least one plane of coagulated tissue by delivering the balanced energy to the target tissue volume from at least one power source via the

electrodes by delivering energy at one of a plurality of energy rates during at least one time period in response to the selected depth of deployment of at least one electrode.

46. A tissue ablation system for use in resecting biological tissue within mammalian bodies, comprising:

means for configuring an electrode array that provides a uniform energy density in at least one target tissue volume using two or more pair of electrodes that include at least one of irregular spacing between one or more pairs of the electrodes and one or more electrode diameters;

means for deploying each electrode of the electrode array at a selected depth in the target tissue volume using the configuration;

means for generating planes of coagulated tissue in the target tissue volume by delivering power to the target tissue volume from at least one power source via the electrodes and controlling the power delivery at two or more rates in response to at least one of elapsed time, a temperature of the target tissue volume, and an impedance of the target tissue volume; and

means for incising the biological tissue in a vicinity of the coagulated tissue and resecting a portion of the biological tissue.

47. A method for performing thermal coagulation necrosis of biological tissue, comprising:

configuring an electrode array that provides a balanced energy density in at least one target tissue volume using two or more pair of bipolar electrodes having a configuration that includes at least one of irregular spacing between one or more pairs of the electrodes and one or more electrode diameters, wherein the irregular spacing includes a first distance between electrodes of each pair of electrodes and a second distance between the pairs of electrodes;

deploying each electrode of the electrode array at a selected depth in the target tissue volume using the configuration; and

generating at least one plane of coagulated tissue by delivering the balanced energy to the target tissue volume from at least one power source via the electrodes and controlling the delivery in response to at least one of elapsed time of the delivery, a temperature of the target tissue volume, and an impedance of the target tissue volume.

48. The method of claim 47, wherein the first distance is equivalent for each pair of electrodes, and the second distance is equivalent between each pair of electrodes.

49. The method of claim 47, wherein controlling the delivery further comprises:

delivering energy at a first polarity to a first electrode of each pair of electrodes and delivering energy at a second polarity to a second electrode of each pair of electrodes for a first period of time; and

delivering energy at the first polarity to the electrodes of a first pair of electrodes and delivering energy at the second polarity to the electrodes of a second pair of electrodes for a second period of time.

50. The method of claim 47, wherein controlling the delivery further comprises:

delivering energy at a first rate for a first period of time to each pair of electrodes; and

delivering energy at a second rate for a second period of time to each pair of electrodes.